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SMALL-SIZE ICE PLANTS FOR FISHERY INDUSTRIES

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, 1974

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SMALL-SIZE ICE PLANTS FOR FISHERY INDUSTRIES

prepared by

H. Lisac
Fishery Industries Division
Department of Fisheries

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PREPARATION OF THIS TECHNICAL PAPER

This document has been prepared within the framework of the Regular Programme activities of the FAO Fishery Industries Division related to an advisory service on fish distribution technology. Use of ice is essential in proper fish distribution, and an increasing interest in the purchase of ice-producing machines is being shown by fish utilization industries. In many parts of the world, and particularly in countries developing their fisheries, the technical knowledge required for ordering small-size ice plants is not readily available. This document is intended to assist government authorities, industry, and trade in the preparation of comprehensive specifications for the type of ice plants wanted.

The document outlines general factors to be taken into consideration when planning the purchase of a small-size ice plant for fishery purposes and lists the detailed information that should be provided to manufacturers of ice-making equipment at the time of ordering.

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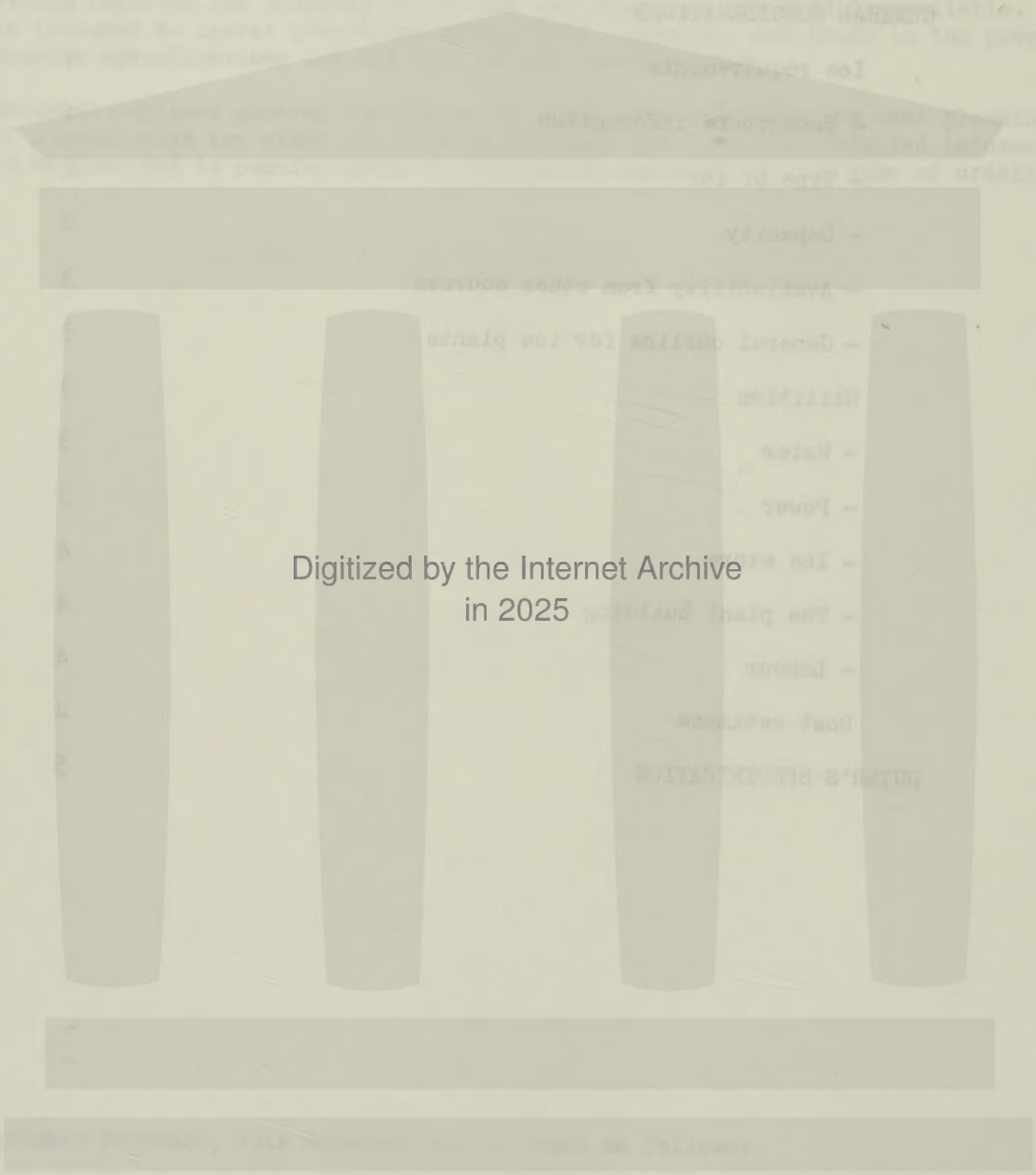

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INTRODUCTION

In most cases the handling and distribution of fresh fish for direct sale or for processing cannot be done properly without cooling the fish. Use of ice is the most common method of cooling to retain the quality of fresh fish for a certain time. This is widely recognized and ice is so used in a great number of small-, medium- and large-scale fish distribution systems and processing industries, although the usage is very often far from satisfactory. Two of the reasons for insufficient use of ice are: inadequate numbers of ice plants, and the relatively high price of the ice. However, there is increasing interest today in the purchase of machines for producing ice, exclusively or mainly for use in fisheries.

Until about a quarter of a century ago, block ice-making plants were the only kind available on the market. They make ice in a batch-type process, up to a 24-h production cycle, and their capacity is relatively large. Indeed, as a rule, it is larger than that required by small-size fish distribution enterprises or retail outlets. With the development of small-ice-making machines, which can continuously deliver ice at rates ranging from less than 50 kg/24 h to 40 tons/24 h, the practical value of these machines for fisheries is obvious.

The information in this document is intended to help the potential buyer to specify exactly the small capacity ice plant he wants from plant manufacturers. It gives the general considerations to be taken into account first, and then lists the detailed information that the buyer must provide if he is to obtain the plant he wants.

GENERAL CONSIDERATIONS

Ice requirements

Background information. The future requirements for ice must first be determined. To this end, answers to the following questions will help:

- Is the ice required exclusively for preservation of fish or for other purposes as well?
- What is the approximate yearly requirement of ice to be used in fisheries and what is the requirement for other purposes?
- How are these requirements distributed over the year?
- Will the ice be used for cooling and keeping freshly caught fish or only for keeping fish previously cooled by ice from other sources?
- Is the ice to be used at sea and, if so, what is the expected length of fishing trip (including outward voyage, time spent on fishing grounds, and return sailing)?
- Will the ice be used for the preservation of fish in chilled sea water?
- What kind of fish handling and preparation is foreseen immediately on landing?
- What are the ambient temperatures?
- In what type of warehouse will the fish be stored?
- How are the iced fish to be transported between landing places and retail outlets and by what means?
- What are the retailing practices?

Replies to these questions, and others which cannot all be listed here, will enable a potential buyer to obtain the essential background information - the purpose for which the ice is required, the quantity required, and where it is required. Later, this background information must be elaborated to be included in the buyer's specification for the ice-making equipment.

Type of ice. Ice is normally produced in one of two forms: as blocks for subsequent crushing or shredding into the "snow ice", and as small, or fragmentary, ice pieces ready for use. Block ice is produced most commonly as 25-kg blocks, but also in 50- or 100-kg or other sizes. Snow ice causes less damage to fish than crushed block ice but tends to coagulate which hampers transfer of heat from fish to ice. This may cause difficulties in handling and transport of the ice.

"Small ice" is a term used to describe many kinds of ice made in small pieces under a variety of names, such as flake, slice, tube, cube, plate, and ribbon ice and many others. Its manufacture and use in fisheries has a number of advantages compared to block ice. The small-ice plant takes up relatively little space, can be fully automatic and needs little supervision and maintenance. Most plants can use either fresh or salt water and output begins soon after the machine is started so there is no need to wait hours for the ice. No crushing is required. The ice, when properly dry and subcooled, flows easily and is easily stored, handled and transported; lending itself well to mechanical, pneumatic or gravity transport systems. The flat shape of flake ice can allow more rapid transfer of heat from fish to ice. The flakes are small and cause less damage to the fish than crushed block ice. The main disadvantage of small ice is that it takes up more room than block ice, and therefore requires larger store space for the same weight. This, however, may be partly offset by better utilization of the space. Small ice also makes comparison with other types of ice difficult, since cooling capacity depends upon the weight of ice used, not the volume.

As already stated, small-ice plants are available in units producing up to 40 tons/24 h. If larger capacity is required, several units can be combined to form plants producing the amount wanted. Such an aggregate has the advantage that maintenance and repair of the equipment may be done without stoppage of production.

Seawater ice must be made rapidly. Often it is not homogeneous and is without a fixed melting point, therefore, some fish stored in such ice may become partially frozen or too salty. The difficulty in maintaining accurate temperature control is the most serious disadvantage of seawater ice. Its main advantages are that it can be produced where there is a shortage of fresh water and that it has no sharp edges to damage fish that have a fragile skin. It is most suitable for initial icing of fish but less so for re-icing. All parts of the plant that come in contact with sea water must be made of material resistant to corrosion. A considerable number of small-ice machines for manufacture of seawater ice have recently been installed on factory ships and fishing vessels, including small trawlers.

Capacity. Particular attention should be given to the capacity of the required plant. If it is too small there will not be enough ice ready to preserve fish properly but if it is too large, installation and operating costs will be unnecessarily high, thus increasing the cost of ice which, for fishery purposes, should be kept at the lowest possible level.

It is particularly important to take into consideration the size of the store room relative to the capacity of ice plant. If of a right size, the store room can be used so as to keep the capacity of the plant at a minimum. Regularity of supply of fish influences this situation. If the fish supply rate is known, it is relatively simple to calculate the quantity of ice required to cool the fish to about 0°C. This could, in the case of fish boxed in plastic containers and iced at sea, amount to approximately 31 kg ice/100 kg of fish caught in waters at 25°C; 19 kg ice/100 kg of fish caught in waters at 15°C; and 6 kg ice/100 kg of fish caught in waters at 5°C. However, additional ice is required to keep the fish cool, depending on the length and condition of storage and transportation. The amounts required may vary considerably from, say, 25 to over 100 kg of ice/100 kg of fish.

At this stage it is also useful to estimate the quantities of ice that may be required at specific points in the distribution scheme (landing place, depots, etc.) and distances between the points.

Availability from other sources. If ice is available from a supplier, its price should be checked and arrangements for the supply at determined times under contract should be carefully investigated. Reliance on outside suppliers to complement one's own production at times of peak landings may be more economical than installing extra plant which would operate at a fraction of capacity during a substantial part of the year. It is advisable at this stage to compare the estimated cost of such ice from both sources.

As storage of ice adds to its cost, capital investment and operation cost of storage should also be estimated. In the case of block ice, the cost of crushing blocks, including inevitable loss in weight and consequently cooling capacity, should also be considered.

Expenses of transport, if the ice is not produced on the spot, consist mainly of manpower or operating costs of mechanical loading and unloading, loss due to melting in transport, and the cost of renting or operating vehicles, which should preferably be insulated or carry insulated containers.

General outline for ice plants. Based on the background information obtained as a result of considering the points outlined above, the general requirements for the planned ice plant(s) can be laid down. They should give basic information on the type of ice desired, the capacity required and, in some cases, the number of ice makers needed.

Utilities

Water. The water frozen in an ice plant is called ice-make-up water. This water is required for every ice plant, and condenser-cooling water for most of them. These two types of water can be of different quality and price.

Ice-make-up water should be potable. Sanitary sea water can also be used. International recommendations for drinking-water standards and methods for determining impurities are laid down in a publication "International standards for drinking water", third edition, published by the World Health Organization, Geneva, in 1971. If the ice-make-up water does not fully satisfy these standards, it can often be adequately treated before use. The most common way is by a purification unit, using chlorine. More information on water treatment can be found in the publication "Operation and control of water treatment processes" by Ch.R. Cox, published by the World Health Organization, Geneva, in 1964. Daily requirements of ice-make-up water expressed in m^3 are approximately identical to the weight of daily ice production expressed in tons. Temperature of ice-make-up water should be as low as possible.

Quality requirements for condenser-cooling water are not as strict as those for ice-make-up water. Any water at low enough temperature, without large suspended particles and of suitable hardness, can be used for the purpose. The lower the water temperature, the lower the investment cost of the condenser, and the higher the production of ice per unit of energy used. The quantity of cooling water required is significantly higher than that of ice-make-up water and largely depends on the type of condensers and the water temperature. In general, the cost of cooling water represents a small percentage of the total cost of ice production. If a source of cooling water is used outside the public supply system, there will be a need to provide a water-pumping station to lift the well, river, lake or sea water to the condensers. Where cooling water is scarce, its recirculation or the use of evaporative condensers should be considered. In this case the operating costs will be kept lower but the capital investment will be higher. In some cases, high cost of cooling by water may justify usage of air-cooled condensers.

Power. The item which costs most in an ice plant is electricity. A constant and reliable electricity supply is vital in ice production. In some sites, power is available from the public supply network. Ice plants are normally driven by electro-motors requiring

3-phase supply. But as the plants are relatively large consumers of electricity, they sometimes require their own transformers to prevent a lowering of voltage. Where there is no reliable public supply, diesel-driven generators are used. In some instances, diesel motors are used to move the compressors of ice plants.

In any case, it is important to find out the characteristics of the available power, in particular: regularity of supply; available power in kWh; tension in Volts; frequency in cycles (or Hz), whether mono- or three-phase, and the price per kWh. If no electricity supply is available, the availability and type of fuel oil, and its price, should be ascertained.

Ice store. An ice store should always be an insulated space and, in most cases, refrigerated. Refrigeration of the store, particularly in the case of small-or medium-size units, should preferably be by a self-contained refrigeration unit(s) independent of the refrigeration system of the plant. The refrigeration capacity of the condensing unit depends mainly on the insulation, size and shape of the store, the ambient temperature and the desired temperature. For example, an average ice store of 40 m^3, would require a condensing unit of about 2 000 kcal/h to keep ice at -2°C at an ambient temperature of 35°C in the shade. An ice store of 15 m^3 would require a condensing unit of about 700 kcal/h to keep ice at -5°C at an ambient temperature of 25°C in the shade. Transfer of ice to storage should preferably be by gravity which is easily achieved if the machine is installed above the store. In estimating operating costs of storage, labour or equipment for loading and unloading ice, and power consumption of the refrigeration unit should be calculated in addition to capital investment. Size of the store depends entirely on storage requirements but should be sufficient to store at least two days production. The approximate densities of the various kinds of ice are: crushed block 640 kg/m^3, tube 540, flake 480, 1 mm-thick slice 390, and block 715 kg/m^3. Stowage rates are: 1.56 m^3/ton for crushed block, 1.85 for tube, 2.1 for flake, 2.56 for 1 mm-thick slice, and 1.40 m^3/ton for block ice.

The plant building. The building which houses the ice maker has the primary function of protecting the ice maker and the ice store from the atmosphere, e.g., sunshine, rain. The building can be of a light construction and roomy enough for the easy installation, operation and maintenance of the plant. Floors should preferably be of concrete and inclined toward drains to ensure adequate drainage. The draining system must be able to absorb large quantities of cooling water. The premises should be located where the transport of ice to fishing vessels and to other main points of usage can be quickly reached. Where appropriate, there should be an access road to the ice store for lorries. The discharge point of the ice store should be above ground level so as to facilitate loading. A small workshop, with tools and spare parts for maintenance and repairs, is required.

Labour. Block-ice plants require more labour, mainly for storage of ice, than do small-ice plants. Except for plant supervisors, one for each shift, the number of plant hands depends largely on the size and mechanization of the plant.

Cost estimate

Since the buying patterns, labour rates, operating costs, insurance and taxes, etc., vary considerably from place to place, such calculations must be entirely governed by local conditions. A cost estimate should include the initial investment cost, annual fixed costs, and operating cost. The main factors to be considered in approximately determining the economic feasibility of an ice plant are the following:

The initial investment includes cost of land, buildings, equipment and engineering. Cost of land covers purchase price, levelling or reclamation, access roads, and first charge for water, electricity and sewage. Cost of the plant building and ice storage includes foundations, masonry work, water installation, including wells, water reservoir or tower, pipeline network and water purification unit, electricity installation, including transformer, and light and power distribution network, and the sewage network. Cost of equipment includes all ice manufacturing and ice storage equipment, and the installed cost of the electric generator and water pumping station, if relevant.

Annual fixed costs may be calculated in many different ways, depending on the local trade pattern and the specific requirements of the plant owner. In principle, they are a sum of depreciation, maintenance, interest on capital invested, insurance, taxes and, sometimes, overheads. In the case of ice plants it is advisable to calculate the depreciation of the premises over a period not exceeding 15 years for insulated structures or 20 years for non-insulated, and of equipment over a period not exceeding 10 years. Annual maintenance cost should not be calculated lower than 2 percent of the total initial cost.

The main operating cost for an ice plant covers power and labour and, in addition, the less significant costs of water, supplies and, sometimes, delivery of ice. Cost of power is best calculated on the basis of the nominal power requirements to produce a ton of ice with the plant concerned, corrected so as to reflect the local operating conditions (e.g., condenser-cooling water temperature). It should also include the power requirements of the auxiliaries (ice storage condensing unit, water pump, ice crusher, etc.). If the relevant information is not at hand, an average power rate of 50 kWh per ton of ice increased per 10 kWh per ton for auxiliaries can be assumed for budgeting purposes in areas where the temperature of condenser-cooling water does not exceed 20°C. Labour requirements are specific and depend on the type and size of plant. For example, a one-ton small-ice plant using a gravity conveyor would require little or no labour except, perhaps, for loading ice into the boats or vehicles. Cost of water includes ice-make-up and condenser-cooling water. The cost of delivery of ice to the point of usage may, on occasions, be significant. It includes the renting or operating vehicles, labour for loading/unloading and the loss of refrigeration capacity of ice due to melting in transport.

The annual operating cost, added to the fixed annual cost, including overheads, and divided by the annual plant production volume, gives the estimated unit cost for a ton of ice.

The estimated cost obtained in this way can be compared with the prices of ice offered by suppliers in the area. When making the comparison, particular attention should be paid to the costs of storage and of delivery to a given point of usage. This procedure should make it possible to evaluate the economic feasibility of the contemplated ice plant.

BUYER'S SPECIFICATION

Having considered the ice requirements, available utilities and economic implications of buying and operating an ice plant as outlined, the potential buyer should supply, in writing, all the information he has about the ice required, the proposed plant, the site and facilities available. The more facts the buyer supplies, the easier it will be for the plant manufacturers to submit competitive tenders that can be compared on a common basis. The following is a check list of the information the buyer should provide when ordering an ice plant:

- For what purpose the ice is mainly to be used?
- Type of ice required (block, small, flake, freshwater, seawater ice, etc.).
- Ice production capacity required (tons of ice/24 h).
- Should the condensing unit preferably be built in the plant or installed as a remote unit?
- Maximum ambient temperature (°C).
- Required ice-store capacity (m^3 and/or tons of ice).
- Should a layout or detailed instruction for building the ice store on the spot be supplied?

- Should a prefabricated store be supplied?
- Should a separate condensing unit with evaporator be supplied for the store?
- Required method of transporting ice from the plant to the store.
- Type of compressor drive wanted (electro-motor or diesel).
- Is there a reliable supply of electricity available?
- Characteristics of the electricity supply: _____Volts, _____cycles(Hz), _____phase.
- Is a separate electric generator required for the ice plant?
- Is diesel oil or other type of oil (specify) available?
- Availability of ice-make-up water:
  - Information on purity
  - Is a water treatment unit required?
  - Temperature (°C)
  - Pressure (kg/cm^2)
- Availability of condenser-cooling water:
  - Type available (tap, well, river, sea, muddy, etc.)
  - Quantity available (m^3/h)
  - Temperature (°C)
  - Pressure (kg/cm^2)
- Is the plant and store building already available or should a layout for the building be suggested by the equipment supplier?
- Available premises for ice plant: length ....(m), width ....(m), height ....(m); and for ice store: length ....(m), width ....(m), height ....(m). The required position of the plant and store in the building with a sketch of site plan.
- Is there any preference for a specific refrigerant (freon, ammonia, etc.) due to its availability or to the level of competence of local refrigeration engineers?
- Should the first and/or spare charge of refrigerant be supplied with the plant?
- Should chemicals for ice-make-up water treatment unit be supplied with the plant and for how long a period?
- Should a set of spare parts be supplied with the plant?
- What maintenance facilities are available?
- What skill is available for installing the plant and putting it into operation?
- Should the plant supplier ensure the engineering skill for installing the plant?
- Are technical descriptions, blueprints and instructions for installation and operation of the plant required and in what language?

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